Bench-Scale Test of Electrochemical Degradation of TCE in Quarry Water from Kokomo Continental Steel Superfund Site

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Introduction:

Electrochemical degradation (ECD) utilizes the high redox potential at the anode and the low redox potential at the cathode to oxidize and/or reduce organic and inorganic contaminants. The focus of our current research is to study the occurrence of cathodic reduction of TCE using graphite cathodes and to identify and quantify the reduction products of TCE. Our results show complete degradation of TCE to non-toxic compounds in kinetically fast reaction using applied voltage range of 10-15 Volts. ECD has the potential to remediate other contaminants such as PAHs, PCBs, fuels, and arsenic in sediments both in-situ and ex-situ. The results may also demonstrate the feasibility of deploying this treatment in the field using cathodic and anodic reactions to treat contaminated sediments.

Mr. Steve Rock obtained a total of eight sample jars from the Markland Avenue Quarry Continental Steel Superfund Site. The samples included one quarry water sample, four sediment samples, and three samples of sediment with slag. Liquid samples from these gars were analyzed after being settled down for four days. Five mls of liquid from each jar was sampled for TCE analysis in the HP headspace autosampler connected to HP 6890 GC/MS. The TCE contents are listed in Table 1 along with chloride ion concentrations in the liquids. The pH of the quarry water is 10.6, and the conductivity is 377 μS.

Bench-Scale Test:

The quarry water has low concentration of TCE and low conductivity. We spike the water with 110 ppm TCE to simulate highly contaminated scenarios in the field. We also increased the conductivity to 13 mS to enhance electrical conductivity of the contaminated water by adding ammonium acetate. We also adjusted the pH to 7 for this preliminary test. This adjustment does not mean that ECD is effective in higher pH conditions. These adjustments were strictly for conducting TCE dechlorination experiment that matches with previous laboratory studies conducted our laboratory. The experiment was conducted according to procedures stated in the QAPP.

The electrochemical reactor consisted of 55 g of 30-50 mesh granular graphite packed column cathode and a platinum gauze anode. Contaminated water was circulated through the reactor by a peristaltic pump via Teflon tubing. The solution tank was continuously stirred with magnetic stirrer and the headspace gas was connected to a gas tank. The pH in solution tank was continuously monitored and the pump controlled circulated flow rate. Gas tank expands as the system pressure under fairly constant pressure of less than 3 psi.

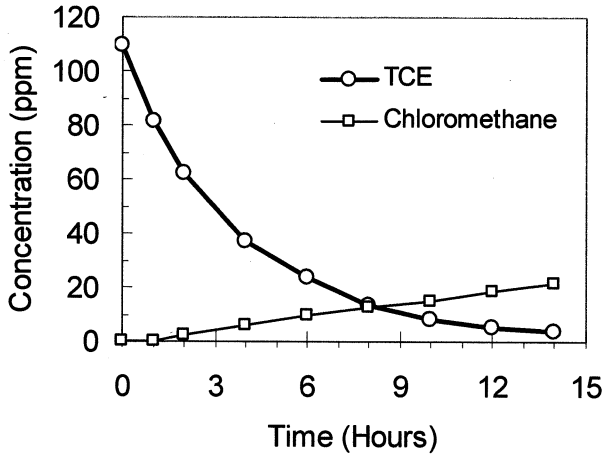

Figure 1. TCE concentration decreased as it is being dechlorinated in the electrochemical reactor.

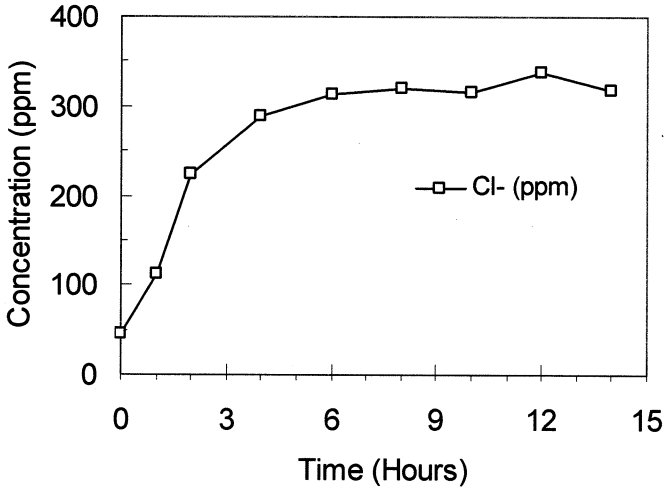

Figure 2. Chloride ion was yielded during the TCE dechlorination process.

Table 1. TCE contractions in the liquids from kokomo samples.

Samples		TCE (mg/l)	Chloride (mg/l)
sediment untumbled		0.27	44.18
sediment untumbled		0.01	39.49
sediment tumbled		0.01	40.68
sediment tumbled		0.31	49.96
sediment + 500g slag		0.31	51.78
sediment + 500g slag*		0.30	55.34
sediment + 1000g slag		0.22	54.88
sediment + 1000g slag		0.01	49.19
quarry water		0.01	44.45

* Sample duplicate.

#	Sample Name	Dilution	Al	As	B	Ba	Be	Ca	Cd	Co	Cr
---	----------		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
BLANK	QC CHECK		-0.001	-0.002	0.003	0.001	0	-0.005	0	0	-0.001
CCV	QC CHECK		10.1	9.98	10.1	9.5	10.3	9.7	10	9.81	9.64
ICV	QC CHECK		21	19.6	20	19.5	19.8	19.3	19	19.3	19.2
1	WATER		0.001	0.023	0.388	10.1	0	8.21	0	0.001	-0.003
2	WATER SLAG		-0.002	0.026	0.412	10.6	0	41.3	0	0	0.102
3	SEDIMENT SLAG		0.002	0.025	0.392	15.3	0	7.81	0	0	-0.003
4	Digestion Sample										
BLANK	QC CHECK		0	-0.002	-0.004	0.004	0	0	0	0	0.002
CCV	QC CHECK		10.4	10.2	9.98	9.77	10.4	10	10.3	10.2	9.87
ICV	QC CHECK		20.7	19.6	19.9	19.4	19.5	19.4	19.1	19.4	19.3

Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.002	-0.012	-0.033	0.007	0	0.007	-0.022	0	0.003	0.001	-0.005	-0.001	-0.003
10.2	9.49	10.2	9.74	9.94	9.86	10.7	10.1	9.64	9.79	10.1	9.82	9.81
19.9	19.4	20.5	19.4	19.6	19.3	21.6	19.5	20.6	19.3	19.7	19.3	19.6
0.014	0.093	79.5	0.459	0.001	0.177	69.4	0.003	0.085	0.015	17.4	0.008	-0.008
0.007	0.072	27.5	8.4	0.001	0.165	56.2	0.002	0.041	0.001	20.8	0.005	-0.001
0.011	0.151	57.7	0.573	0.002	0.186	49.6	0.004	0.077	0.102	21.8	0.008	-0.008
0.001	-0.004	0.016	0.002	0	-0.001	-0.012	0.001	0.017	-0.005	-0.002	-0.001	-0.001
10.1	9.96	10.7	9.89	10.2	10.2	10.3	10.2	9.64	10.2	10.6	10	9.99
20.1	19.6	20.7	19.6	19.7	19.4	21.1	19.3	19.9	19.4	20.1	19.5	19.7

Si	Sn	Ti	Tl	V	Zn			
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L			
0.004	-0.002	0.001	-0.027	0.003	0			
9.73	9.38	9.21	9.68	9.54	9.9			
19.5	21.6	21.1	19.3	19.1	19.6			
3.49	0.006	0.002	0.078	-0.013	0.003			
4.36	0.001	0.001	0.097	0.002	0.007			
1.81	0.003	0.003	0.083	-0.004	0.029			
-0.001	0.001	0.001	0.017	-0.004	0			
9.89	9.49	F 8.95	9.86	9.47	10			
19.8	21.2	20.5	19.2	19.3	19.5